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MOVEMENTS OF PRICES.

ECONOMIC well-being consists in the individual's command over the necessities, comforts and luxuries of life. This power of command is measured by his income, which is expressed in terms of money and is called wages, salary, interest, profit, rent, *etc.* How far this income will go is determined by the prices of commodities and of personal services, also expressed in terms of money. Fluctuations of income are of direct importance to each individual. Fluctuations in prices are of equal importance, or rather they are the same thing, for they increase or diminish real income. Economists recognize this fact when they speak of real wages as contrasted with nominal or money wages, and they have labored with great zeal at this distinction.

Individuals are keenly alive to movements in the prices of those commodities in which they are interested. The producer who buys raw material and turns out finished products exercises his skill and business sagacity in taking advantage of low prices for his purchases and high prices for his sales. The relation between the two determines his profit. The market price of great staples like coal or iron determines the investment of capital in mines, foundries, *etc.*, or its withdrawal — determines, that is, the expansion or restriction of these enterprises. The condition of the prices of such staples is, moreover, often looked upon as a barometer of general trade prospects. When, after a period of depression, the price of iron begins to rise, the change denotes increased demand, which means increased activity, not only in the production of iron, but also in railroads and in all other industries using iron.

Prices often have wide-reaching importance socially, as well as economically. Thus, low prices of agricultural products lead in England to reduction of rents, embarrassment of landlords and abandonment of farms; in Ireland, to inability to pay even "fair rent" and to further revision of rent; in the United

States, to discontent and repudiation of mortgage indebtedness, to silver crazes and populist programs; in Germany and France, to duties on cereals and meats and to a general protective policy. A high price of bread is a fruitful cause of political revolution.

Of greater importance is the phenomenon known as a general rise or fall in prices — a change in the whole price-level. Some of the more marked changes of this character — notably those which occurred in the later period of the Roman Empire, in the period following the discovery of America (especially after the opening of Potosi, 1545) and in the twenty-five years following the California gold discoveries — have been exploited as historic illustrations of the effect of a decrease or increase in the supply of money. The most recent of these changes in price-level — the great fall since 1873 — has led to the bimetallic movement and the free-silver struggle in the United States. In these last struggles enormous interests have been supposed to be involved. It is asserted that the well-being of whole classes has been affected; that the system of deferred payments has been so dislocated and distorted as to work grievous injustice; and that the community at large is undergoing the agony of slow but sure decadence and death. "The permanent industrial crisis" is the mildest term which has been used to describe the situation; and the fall of the Roman Empire — which, in accordance with Allison's theory, is attributed to scarcity of money — has been declared to afford the closest analogy to the probable future of the modern world.

The attempt to prove these statements rests upon three theses:

(1) That we have a scientific apparatus for determining and measuring changes in price-level.

(2) That we can trace the effect of such changes upon the community, upon classes and upon individuals.

(3) That our theory of money is sufficiently precise to enable us (*a*) to determine the relation between money and prices; (*b*) to control prices by manipulating money; and (*c*) to remedy in this manner any evil effects which we may have discovered.

The intense interest felt in this subject during the last twenty-five years has led to remarkable activity, both in the development of pure theory and in the study of experience, for the purpose of elucidating the above problems. This activity has not been thrown away. While all three problems probably appeared simpler twenty-five years ago than they do now, we have become aware of limitations to theory and imperfections in method which are of the utmost importance. It cannot be said, however, that our knowledge is as yet in a satisfactory state: discussion has, indeed, revealed great diversity of opinion. But it has sifted out a good deal that was superficial; and, while that which is left has lost the simplicity which came from superficiality, it is none the less valuable on that account. As the problem of prices is of perennial interest and as the money question cannot yet be said to be settled, even for the immediate future, it may be useful to put in concise form the results of the discussion up to the present time. In this paper I shall consider the general subject of movements of prices and the way we measure them, reserving for a future time the more practical questions as to the effect of changes in prices and the relation between money and prices.

Index Numbers. — We have numberless records of prices. Every sale of commodities involves a price; and, wherever credit is given, each transaction results in an entry on the merchant's books. Further, we have markets and exchanges where prices are recorded from day to day, or even from hour to hour, or from moment to moment. We need a method which will gather together these individual phenomena into a formula or expression that will enable us to study general changes in prices and to correlate such changes with other facts of the economic world. The necessary steps in this procedure are: (1) to constitute representative prices for single commodities for a given period, such as a day, a week, a month or a year; (2) to arrange these prices so as to show proportionate changes from period to period, as from year to year or from decade to decade; (3) to combine the prices of a sufficient number of commodities, so as to get a general price-level, for the purpose of detecting

general movements of prices. The expression thus obtained is known as an index number.

The construction of an index number is comparatively simple and is illustrated by Mr. Sauerbeck as follows:¹—

Take the average price of English wheat for a certain period (in this case 1867–77) as a base. Then compare the price in any other year with that of the basal period and calculate the percentage. Thus :

INDEX NUMBERS FOR ENGLISH WHEAT.

	s.	d.	INDEX.	
Average 1867–77	54	6	100	average point.
“ 1855	74	8	137	or 37 per cent above the average point.
“ 1897	30	2	55	or 45 per cent below the average point.

The index number is a simple percentage based on the average. When the prices from year to year of an important commodity, like wheat, are arranged in this way, or are depicted graphically by a falling or rising line, we have a presentation of the course of prices which is especially interesting when extended over long periods. We can calculate a similar index number for any other commodity of which we can get prices. The results, however, may be more or less contradictory; for the prices of some commodities may rise, while those of others fall; or they may rise and fall together, but in varying degree.

To form a general judgment as to whether, on the whole, prices have risen or fallen, there are two devices open to us. A very simple one is to compare the numbers that have risen with the numbers that have fallen. This device is employed by Professor Falkner, who, comparing the wholesale prices of 223 commodities in 1891 with their prices in 1860, finds that 61 commodities have risen in price, 9 have remained stationary and 153 have fallen. This shows, of course, in a general way a greater tendency to fall than to rise. Much, however, depends upon the articles chosen. Thus, out of 153 articles

¹ *Journal of Royal Statistical Society*, LXI, 156 (1898).

which, according to Professor Falkner's table, have fallen in price, no less than 25 are different kinds of jackknives.¹ This method is not a convenient one, especially when continued from year to year.

A second device is simply to average the index numbers of various commodities, and thus to obtain a general index number for all the commodities observed. Mr. Sauerbeck illustrates this procedure as follows :

INDEX NUMBER BY GROUPS OF COMMODITIES. (1897.)

		TOTAL. AVERAGE.	
1. Vegetable food (wheat, flour, corn, barley, oats, maize, potatoes and rice)	8 index nos.	480	60
2. Animal food (beef, mutton, pork, bacon and butter)	7 " "	554	79
3. Sugar, coffee and tea	4 " "	209	52
Foods	19 " "	1243	65
4. Minerals (iron, copper, tin, lead and coal)	7 " "	460	66
5. Textiles (cotton, flax, hemp, jute, wool and silks)	8 " "	407	51
6. Sundry materials (hides, leather, tallow, oils, soda, nitrate, indigo and timber)	11 " "	678	62
Materials	26 " "	1545	59
General average	45 " "	2788	62

Such a table means simply this: that a certain aggregate of commodities — a bushel of wheat, a barrel of flour, a ton of iron, *etc.* — sold for such sums in the years 1867–77, and for such other sums in the year 1897, that these prices were related to each other as 100 to 62. Such a table does not show the effects of the change on the community or on different classes in the community, nor does it show the cause of the change. It gives us the general price-level of a particular year as compared with the standard period, showing whether the change has been upward or downward and how great it has been. By grouping the commodities we get further information — namely, that the fall in certain commodities has been greater or less than in others.

¹ Report of Senate Committee on Wholesale Prices, I, 56.

If we now carry out our calculations for other years, we have a series of index numbers as follows:

SUMMARY OF INDEX NUMBERS. (1867-77 = 100.)

1878	87	1888	70
1879	83	1889	72
1880	88	1890	72
1881	85	1891	72
1882	84	1892	68
1883	82	1893	68
1884	76	1894	63
1885	72	1895	62
1886	69	1896	61
1887	68	1897	62

The same system may be carried backwards, and this has been done by Mr. Sauerbeck. In order to eliminate the frequent changes from year to year, we may, moreover, calculate a number for each decade, so as to have such a series as the following:

INDEX NUMBERS BY DECADES.

1818-27	111	1877-86	82	1883-92	72
1828-37	93	1878-87	79	1884-93	71
1838-47	93	1879-88	78	1885-94	69
1848-57	89	1880-89	76	1886-95	68
1858-67	99	1881-90	75	1887-96	68
1868-77	100	1882-91	74	1888-97	67

We have here a simple statistical device for expressing by a group of figures the complicated phenomena of prices. It expresses an objective fact — namely, that, on the whole, prices are higher or lower; or, rather, it enables us to affirm with some degree of precision that which common observation would confirm — namely, that things are (say) cheaper now than they were twenty-five years ago. It seems to be analogous to a record of crimes or of suicides, continued from year to year, which enables us to express a judgment that crime or suicide is increasing or decreasing. Such a figure may conceal in itself many estimates, approximations, imperfections and even positive errors, and may

yet be sufficient for its primary purpose—to serve as a rough expression of a general movement. When we are not expressing a precise judgment or basing important positive social action upon such proof, we can take this rough index for what it is worth.

But it constantly happens that, after having reached a general formula of this sort, men become, as it were, fascinated by their own handiwork, and use the instrument for purposes for which it is unfitted. They forget all the assumptions that were introduced while it was in the making, and conceive that the final result expresses accurately and precisely what it is fitted to do only generally and roughly. An increasing rate of convictions for crime, for instance, does not necessarily show increasing criminality; for serious crime may be diminishing, while, owing to increased legislative activity or greater administrative efficiency, arrests for mere police offenses are increasing. On the other hand, a decreased criminal rate, brought about by the suppression of petty larceny but accompanied by an increase of offenses against morality, could not be viewed with satisfaction. Similarly, the crude average wage calculated by dividing the amount paid in wages in 1880 by the number of workmen employed, which contained almost every possible statistical fallacy and never had even the authority of the census officials behind it, has been used as the basis for all sorts of arguments about the rate of profit, the distribution of wealth and the oppressive character of the modern industrial organization.¹

In like manner men have been fascinated by the index number. It has seemed to give us a grip upon the complex world of business about us in its most important manifestation. The concrete phenomena of prices, in all their bewildering variety, are here made objective and reduced to a measurable expression, so that we can manipulate them as we will. We can say that the index number proves that prices are higher or

¹ So widespread has been the use of this average wage that the Commissioner of Labor thought it wise to expose the fallacy in the *Bulletin of the Department of Labor*, March, 1896.

lower, that prices are rising or falling, that certain things have become cheaper or dearer. This is a justifiable use of the index number. Then, however, it is but a step to say that certain persons or classes are better or worse off, *because* prices have risen or fallen, and to try to measure the degree of benefit or injury. Next, it is only a step further to attribute the rise or fall of prices to some other phenomenon — such as the decreasing production of gold, the demonetization of silver or the monopolistic control of industry — as the precise effect of a specific cause.

An examination of the technique of index numbers will show why they are fitted to perform the first of these functions, and what are the difficulties in the way of using them to solve problems of the second and third class. For this purpose we have abundant material. There are several series of index numbers which have been carried on with great care for many years. Sir Robert Giffen¹ ascribes the honor of inventing the device to Jevons, who arranged the prices in Tooke on the plan of index numbers, and based upon them his *Essay on the Depreciation of Gold*, which established his reputation as an economist.² Newmarch had already published the prices of twenty-two commodities in the *Journal of the Statistical Society* for 1859–61, and, using the average price for 1845–50 as a base, had calculated an index for each commodity. These quotations were afterwards continued in the *Economist's Annual Commercial History*, and a combination of these figures made up the famous *Economist* index number, using 2200 as a base (1845–50). Since then we have had Mr. Sauerbeck's index number, based on the wholesale prices of 45 commodities and published annually in the *Journal of the Royal Statistical Society*.³ Another famous index number is that of Soetbeer, based for the most part on Hamburg prices.⁴ Finally, we have Professor

¹ Testimony before the Gold and Silver Commission, First Report, Question 697.

² Republished in his *Investigations in Currency and Finance*.

³ Exhaustively explained by Mr. Sauerbeck in the *Journal* for 1886.

⁴ Contained in his "*Materialien*." An English translation was published in the Final Report of the Gold and Silver Commission, and also in U. S. Consular Reports, No. 87.

Falkner's index number, based on the wholesale prices of 223 commodities, published in the *Senate Report on Wholesale Prices*, known as the "Aldrich Report."¹ Besides these there are numerous other index numbers.

Index numbers have been subjected to severe criticism, especially before the Commission on Gold and Silver, whose *Final Report* summed up the testimony for and against them (p. 21). Further, they have been subjected to a rigorous scientific analysis by a committee of the British Association for the Advancement of Science, whose memoranda, drawn up by Professor Edgeworth (*Reports* for 1887-90), constitute the most brilliant and exhaustive treatment, from the points of view of mathematics and of logic, of the whole question. Upon the basis of all this material, it is comparatively easy to point out those questions of technique in respect to index numbers which are of scientific interest.

Prices and Qualities. — The first question of technique — in itself of sufficient difficulty — is simply a practical one : namely, how to fix the price of each commodity that enters into an index number, and to be sure that the article known under a particular name, such as iron, tea or cotton cloth, continues to be always of the same quality;² for it is evident that if "tea" at one time means one quality and at a later period another, an apparent change in price means nothing.

Wholesale prices are commonly used for index numbers, because such prices can readily be obtained with some degree of precision. They are of value because of their publicity, from the fact that they are fixed by strenuous competition and on account of the magnitude of the transactions involved. They may be taken, in the first place, from official records (for example, the Gazette Prices of English Wheat), from trade lists of large firms (such as Pixley and Abel's Quotations of the Price of Silver), from market reports of commercial and trade papers, or from the books of business firms giving actual trans-

¹ Professor Falkner gives also a valuable study and comparison of other index numbers.

² See Falkner, "Theory and Practice of Price Statistics," in Publications of the American Statistical Association, III, 119, 1892.

actions (Falkner's method). A second source of information is such records of the prices of certain standard commodities as are found in the accounts of the purchases of public institutions, such as hospitals, poorhouses, army and navy boards, *etc.* (Soetbeer and Falkner). A third expedient is to take the declared values of certain important articles of import or export, and divide the total values by the quantities, thus obtaining an average price (Soetbeer). Market prices for a certain date may be used (*Economist*) or the average of twelve monthly prices may be taken (Sauerbeck).

The question of quality is comparatively easy to solve, as regards the wholesale prices of standard commodities which are quoted on a market, though even here there are some changes. For instance, wheat is not always of the same milling quality from year to year; but here, as in other similar cases, it is comparatively easy to get expert business opinion upon the nature and importance of the change. Occasionally, too, some articles lose their relative importance and new articles come into use, so that it is expedient to make substitutions.¹

All these difficulties are of minor importance when we look upon our index number simply as a rough indicator of changes in the price-level. They assume another aspect, however, when we consider the effect of such changes upon individuals, or affirm that a certain change is due to fluctuations in the quantity of money used as a medium of exchange. Retail prices are then of consequence, and changes of quality become of vital interest.

The Choice of a Basal Period. — To choose the right basal period for an index number is a matter of considerable consequence. The *Economist* and Soetbeer use as a base the period 1845-50 or 1847-50 — a time of low prices. Mr. Sauerbeck uses the period 1867-77, which is mainly a time of high prices. Mr. Falkner uses the single year 1860. The average of a period, however, seems better than the figure for any single year. If the base is low, a rise in prices will be accentuated;

¹ See the interesting testimony on these points by Messrs. Giffen and Sauerbeck before the Gold and Silver Commission (First Report).

if the base is high, a fall in prices will be accentuated. Thus, entirely different impressions are produced by considering the index number for 1891 as 109.19, according to Soetbeer; 102, according to the *Economist*; 92.2, according to Falkner; or 72, according to Sauerbeck. Of course, with the actual figures, any number may be transposed to any other base; but this is a matter of some labor. As a rule, index numbers are used for supporting certain theses, and that one is chosen which makes the most striking showing for the end in view.

Choice of Commodities. — Ordinary index numbers vary greatly as to the number of commodities whose prices are used. The *Economist* has 22; Sauerbeck, 45; Soetbeer, 114; and Falkner, 223. At first blush, it would seem that we should have as many articles as possible. But, aside from the technical difficulties of getting the prices of a great number of articles and the increased risk of changes in quality, it may plausibly be affirmed that, if we pick out representative articles, especially raw materials, the prices of other articles, especially those manufactured from our representative articles, will probably vary in the same direction (at least), if not in the same ratio. Mr. Sauerbeck has experimented in this way and has found that the index number for 1885 would be:¹—

Taking 45 principal articles	71.9
“ 61 sundry articles, food and raw material	84.8
“ 51 manufactured and partly man’f’d articles . . .	73.6
“ 157 articles	77.5

This seems to show that an additional number of articles affects the index number somewhat, but not to a very great extent.

Professor Falkner has experimented by reducing the four index numbers to the same base, — namely, 1860, — and finds that the index number for 1891 would be:²—

According to the <i>Economist</i>	(22 articles)	81.
“ “ Sauerbeck	(45 “)	75.4
“ “ Soetbeer	(114 “)	90.3
“ “ Falkner	(223 “)	92.2

¹ Gold and Silver Commission, First Report, p. 321.

² Senate Report on Wholesale Prices, I, 226, 255, 295.

Here again the introduction of a large number of articles seems to raise the index number.

In a similar way, Professor Pierson finds that, taking 1861-70 as a base, Soetbeer's number for the period 1881-83 shows scarcely any change in price-level, while Sauerbeck's shows a very considerable fall.¹ According to Pierson, Soetbeer's number is to be preferred, simply because it includes a larger number of commodities. Sauerbeck has answered that these additional commodities are, as a rule, of small importance and very eccentric in their variations.² Hops, for instance, rose from 255 in 1881 to 413 in 1882, and to as much as 517 in 1883, declining to 243 in 1885 and to 213 in 1886. That Soetbeer's numbers do not fall in 1882 and 1883 can be ascribed to the influence of this single article, since its rise affected the two years to the extent of 1.4 and 2.3 per cent, respectively. A striking example of the influence of a single quotation has been given by Professor Falkner.³ His index number for all food-stuffs shows a rise from 100 in 1860 to 103.9 in 1891, and this rise is in marked contrast with the fall of the great mass of commodities. This is, moreover, a very important fact, since food is the most important item of consumption. But among the articles which go to form this important group are four kinds of fish. All of these show a rising price since 1860, and the single quotation of codfish gives an index number of 312 for 1891, on the basis of 100 for 1860. If, however, we exclude the single item codfish from the index number of food for 1891, it becomes 99.9; while if we exclude all four quotations of fish, the number becomes 94.9, and the rise of $3\frac{1}{3}$ per cent is turned into the very considerable fall of 5 per cent.

All these considerations seem to show that, while almost any index number will give us the general course of prices, the evidence furnished by index numbers becomes more and more uncertain as we try to make it more specific.

Articles according to their Importance. — In an ordinary index number each commodity has an equal influence on the

¹ *British Economic Journal*, V, 109.

² *Ibid.*, p. 161.

³ Report on Wholesale Prices, I, 59.

final average. The consequence is that a fall of 25 per cent in the price of wheat would be offset by a rise of 25 per cent in the price of indigo. In such a case the index number would not change, although of course it would be absurd to say that no change in price-level had occurred. This defect in ordinary index numbers has always been recognized. Accordingly, an attempt is sometimes made to offset it by introducing the same commodity more than once. Thus the *Economist* gives to cotton four numbers out of twenty-two; but, as has often been pointed out, this very expedient resulted in abnormally raising the *Economist* index number during the cotton famine of 1862-65. Again, among the 45 commodities in the Sauerbeck number, wheat is represented twice and flour once, while beef, mutton, sugar, iron, coal, cotton, wool and oil are each represented twice. This is evidently a very rough way of equalizing the importance of commodities.

A more scientific procedure is to seek a system of "weights" which shall adjust the relative share of each commodity in determining the final index number. The classical example of such a calculation is that of Mr. Palgrave, prepared for the Commission on the Depression of Trade. He took the *Economist* numbers from 1865 to 1885 and weighted each commodity according to its total value in the consumption of the United Kingdom. For instance, in 1885 the total value of wheat imported and home produced in England was estimated at 49,360,000 pounds sterling, while the net value of indigo (imports less re-exports) was roughly 600,000 pounds sterling. Wheat, therefore, was 82 times as important as indigo; and a rise of 1 per cent in wheat should count as much as a rise of 82 per cent in indigo. Other articles were estimated in the same way. For some the estimates were very difficult: the consumption of meat, for instance, was reached by taking the total number of cattle, sheep and pigs in the country and allowing an average mortality and an average price.

The chief question of interest is, how far this system of weighting changes the index number. An answer is given in the following table:¹—

¹ Commission on Depression of Trade, Third Report, p. 328.

ECONOMIST INDEX NUMBER SHOWING DIFFERENCE BETWEEN
SIMPLE AND WEIGHTED AVERAGE.

YEAR.	SIMPLE.	WEIGHTED.	YEAR.	SIMPLE.	WEIGHTED.
1865-69	100	100	1878	87	95
1870	91	90	1879	76	82
1871	90	93	1880	87	89
1872	97	100	1881	81	93
1873	102	104	1882	83	87
1874	100	108	1883	80	88
1875	95	97	1884	75	80
1876	93	99	1885	70	76
1877	94	100			

Much has been made of this experiment, as confirming the accuracy of the general system of index numbers. It will, indeed, be observed that the changes in the two series usually correspond in general direction. The weighted average seems, as a rule, to remain somewhat above the simple; and in some cases — as, for instance, in 1878 and 1881 — departs considerably from it. This may be explained, however, by the small number of commodities (22) used by the *Economist*, which accentuates the difference between the two methods, when an important commodity fluctuates considerably in price.

A better test of the influence of weighting is furnished by Mr. Sauerbeck.¹ His ordinary number consists of the simple average of his 45 commodities. He is accustomed to test this in two ways. First, by a method similar to Mr. Palgrave's, he gives to each article a weight corresponding to its importance in the United Kingdom. The result for 1897 was that the weighted mean was 62.5, instead of 62, the simple mean. His second system of weighting is as follows: Take the quantity produced of each commodity — say, during the year 1897 — and, multiplying by the price, obtain the total value for the year 1897. Now, taking the same quantity, estimate what would have been its value at the price in the standard period, 1867-77. In this way find the sums of the values of all the commodities at the two periods, and the difference between

¹ *Journal of the Royal Statistical Society*, 1898, p. 154.

the two must be due to a change in prices. For instance, the total value of these 45 commodities in 1897 was 464.2 million pounds sterling. The value of the same quantities at the prices of 1867-77 would have been 731.5 million pounds sterling. The proportion between the two is as 63.5 to 100. The proportionate price for 1897 — that is, the index number — is therefore 63.5, instead of 62, according to the simple average.

Many other experiments have been made in weighting index numbers. It has been shown, for instance, that it is not necessary to calculate the exact importance of the different commodities for each year. Thus, Mr. Sauerbeck uses in one calculation the average of importance for the three years 1894-96, and in a second calculation the average for the five years 1871-75. In the first case the index number for 1897 is 62.5, and in the second 62.6.

There remains one difficulty which no system of weighting will meet — namely, the case of new commodities coming extensively into use after the system has been constructed. The change from year to year will probably not be great, but eventually it will be considerable — as, for example, in the case of the introduction of petroleum for light. There seems to be no way of meeting this difficulty except by constructing a new base.

The necessary conclusion from all these experiments seems to be that, for the purpose of following roughly the general course of prices, almost any system of weighting, however imperfect, is sufficient. When we come to consider the effects of changes in the price-level and the relations between money and prices, however, the imperfections we have noted become of vital importance. Our “estimates” then betray their crudeness, and it becomes increasingly difficult and necessary to decide upon the relative importance of commodities.

Methods of Averaging. — A final point of technique is the method of averaging the various single index numbers so as to form the general index number. The method commonly used is the simple arithmetic mean. Where the commodities are weighted according to their importance, we have the weighted arithmetic mean, which is certainly more correct in principle,

although in ordinary cases the two results are so nearly the same that the simpler method can be employed. On the other hand, Jevons, in his famous investigation on gold and prices, used the geometric mean, and defended it on the following grounds: If we have two commodities, one of which doubles in price while the other remains stationary, according to the simple arithmetic mean the average rise in price is 50 per cent: that is, the combined index number for the first period would be 100, and that for the second would be 150. The number 150, however, which is supposed to be the mean, does not bear the same per cent relation to 100 that 200 does to 150. The true mean is 141, which is 41 per cent above 100, just as 200 is 41 per cent above 141. This is the geometric mean.

This reasoning of Jevons was disputed by Laspeyres, who gave the following illustration: Suppose one ounce of gold buys either one pound of cocoa or one pound of cloves. Suppose, then, that the price of one commodity doubles, while that of the other sinks one-half. According to the geometric mean, the price-level remains unchanged. But what has really happened is that now it has become needful to pay two and one-half ounces of gold for the same commodities that formerly could be bought for two ounces: that is, it requires 25 per cent more money to buy the same commodities. The arithmetic mean of the index numbers 200 and 50 would be 125, indicating precisely this rise of 25 per cent. To this criticism Jevons made no adequate rejoinder, except to say that the geometric mean gave rather lower results than the arithmetic, and so was safer for his purpose—the study of a rise in prices.

Mr. Sauerbeck has experimented with the geometric mean on his index number, reaching the following results:¹

ACCORDING TO THE	1880	1894	1895
Geometric mean	87.0	60.9	60.4
Arithmetic mean	87.8	62.9	62.1
Average, weighted	87.3	62.0	60.8

Here the geometric mean gives a slightly lower figure than the simple arithmetic mean, but the results do not differ materially.

¹ *Journal of the Royal Statistical Society*, 1896, p. 193.

Professor Edgeworth has come to the conclusion that the geometric mean is sometimes preferable, as diminishing the influence of extreme quotations, although the result is very much the same. Other methods of averaging (the so-called "median" and the "weighted median") have also been tried by Professor Edgeworth.¹ If we use the same data, however, the different methods seem to yield about the same results. In fact, Professor Edgeworth has experimented on the same data with seven different methods, and has reached the following index numbers for 1885: 70, 70.6, 73, 69, 72, 72, 69.5.²

Conclusion.— This remarkable agreement in the different methods of calculating index numbers has led to two conclusions. The first of these is expressed by Mr. Giffen as follows:

The articles as to which records of prices are obtainable being themselves only a portion of the whole, nearly as good a final result may apparently be arrived at by a selection without bias, according to no better principle than accessibility of record, as by careful attention to weighting. . . . Practically the committee would recommend the use of a weighted index number of some kind as, on the whole, commanding more confidence. . . . A weighted index number in one aspect is almost an unnecessary precaution to secure accuracy, though on the whole the committee recommend it.³

A second conclusion which is sometimes drawn is that this consensus of results greatly strengthens the authority of the index number as a scientific method of accurately measuring changes in price-level. It has, however, been shown (again by Professor Edgeworth) that this is due simply to the general law of probability: in other words, that where we have an average drawn from a series of numbers, the divergences from that average, due to any system of weighting which is unbiased, will give approximately the same result. The error of any index number will be found to depend in a definite manner upon six distinct circumstances.

¹ British Association for the Advancement of Science, Report for 1889, p. 156.

² *Ibid.*, 1888, p. 197.

³ As summarized by Professor Edgeworth in his article on "Index Numbers," in Palgrave's Dictionary of Political Economy.

The erroneousness of the result is greater, the greater the inaccuracy of the data; *viz.*, the weights and the (comparative) prices. The erroneousness of the result is also greater, the greater the inequality of the weights and the greater the inequality of the price-returns. Lastly, the result is more accurate, the greater the number of the data, and the smaller the number of omitted articles. These circumstances are not all equally operative. Other things being the same, the inaccuracy of the price-returns affects the result more than the inaccuracy of the weights; and the inequality of the price-returns more than the inequality of the weights.¹

We are not here concerned with the proof of these theses, so brilliantly demonstrated by the author of the memoranda referred to. We have already seen that the different numbers do vary considerably from each other, that the price-returns are liable to inaccuracy, that the number of articles varies considerably and that the weighting is dependent upon rough estimates of the importance of the articles in production and consumption. The general agreement of the numbers is sufficient to confirm us in the use of the index number as a general indicator of the direction of changes in price; but the differences in the results show us that the method is inadequate to give us the exact measure of the change. The criteria laid down by Professor Edgeworth show us that in order to study the effects of price-changes on classes and individuals we must have, besides the information afforded by the ordinary index number, the following additional data:

- (1) Some idea of the connection between retail and wholesale prices, in order to bring the movement of prices into direct connection with the cost of living for the individual;
- (2) Some method of estimating the relative importance of single commodities in the expenditure of the individual;
- (3) Some estimate of changes in income, or statistics of wages, in order to measure the effect of changes in price-level on the real economic condition of the individual.

These things remain to be examined.

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¹ Report of British Association, 1888, p. 197.